

CLAIMS:

1. Integrated circuitry comprising a capacitor comprising a first capacitor electrode, a second capacitor electrode and a high K capacitor dielectric region received therebetween; the high K capacitor dielectric region comprising a high K substantially amorphous material layer and a high K substantially crystalline material layer.

2. The integrated circuitry of claim 1 wherein the high K substantially amorphous material and the high K substantially crystalline material constitute the same chemical composition.

3. The integrated circuitry of claim 1 wherein the high K substantially amorphous material and the high K substantially crystalline material constitute different chemical compositions.

4. The integrated circuitry of claim 1 wherein at least one of the first and second electrodes comprises elemental metal, metal alloy, conductive metal oxides, or mixtures thereof.

5. The integrated circuitry of claim 1 wherein at least one of the high K substantially amorphous material layer and the high K substantially crystalline material layer contacts at least one of the first capacitor electrode and the second capacitor electrode.

1           6.    The integrated circuitry of claim 1 wherein the high K  
2 substantially amorphous material layer contacts at least one of the first  
3 capacitor electrode and the second capacitor electrode.

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5           7.    The integrated circuitry of claim 6 wherein the high K  
6 substantially amorphous material layer contacts only one of the first capacitor  
7 electrode and the second capacitor electrode.

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9           8.    The integrated circuitry of claim 1 wherein the high K  
10 substantially amorphous material layer contacts one of the first and second  
11 capacitor electrodes and the high K substantially crystalline material layer  
12 contacts the other of the first and second capacitor electrodes.

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14           9.    The integrated circuitry of claim 1 wherein the high K capacitor  
15 dielectric region is the only capacitor dielectric region received between the  
16 first and second capacitor electrodes, and consists essentially of the high K  
17 substantially amorphous material layer and the high K substantially crystalline  
18 material layer.

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20           10.   The integrated circuitry of claim 1 wherein the high K  
21 substantially amorphous material layer is at least 98% amorphous, and the  
22 high K substantially crystalline material layer is at least 98% crystalline.  
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1 11. The integrated circuitry of claim 1 comprising a semiconductor  
2 substrate, the capacitor being received at least partially over the semiconductor  
3 substrate, the high K substantially crystalline material layer being received  
4 between the semiconductor substrate and the high K substantially amorphous  
5 material layer.

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7 12. The integrated circuitry of claim 11 wherein the semiconductor  
8 substrate comprises bulk monocrystalline silicon.

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10 13. The integrated circuitry of claim 11 wherein at least one of the  
11 high K substantially amorphous material layer and the high K substantially  
12 crystalline material layer contacts at least one of the first capacitor electrode  
13 and the second capacitor electrode.

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15 14. The integrated circuitry of claim 11 wherein the high K  
16 substantially amorphous material layer contacts at least one of the first  
17 capacitor electrode and the second capacitor electrode.

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19 15. The integrated circuitry of claim 1 comprising a semiconductor  
20 substrate, the capacitor being received at least partially over the semiconductor  
21 substrate, the high K substantially amorphous material layer being received  
22 between the semiconductor substrate and the high K substantially crystalline  
23 material layer.  
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suba1  
cont.

16. The integrated circuitry of claim 15 wherein the semiconductor substrate comprising bulk monocrystalline silicon.

17 Integrated circuitry comprising a capacitor comprising a first capacitor electrode, a second capacitor electrode and a  $Ta_2O_5$  comprising capacitor dielectric region received therebetween; the  $Ta_2O_5$  comprising region comprising a substantially amorphous  $Ta_2O_5$  comprising layer and a substantially crystalline  $Ta_2O_5$  comprising layer.

18. The integrated circuitry of claim 17 wherein at least one of the substantially amorphous  $Ta_2O_5$  comprising layer and the substantially crystalline  $Ta_2O_5$  comprising layer contacts at least one of the first capacitor electrode and the second capacitor electrode.

19. The integrated circuitry of claim 17 wherein the substantially amorphous  $Ta_2O_5$  comprising layer contacts at least one of the first capacitor electrode and the second capacitor electrode.

20. The integrated circuitry of claim 19 wherein the substantially amorphous  $Ta_2O_5$  comprising layer contacts only one of the first capacitor electrode and the second capacitor electrode.

1 21. The integrated circuitry of claim 17 wherein the substantially  
2 amorphous  $Ta_2O_5$  comprising layer contacts one of the first and second  
3 capacitor electrodes and the substantially crystalline  $Ta_2O_5$  comprising layer  
4 contacts the other of the first and second capacitor electrodes.

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6 22. The integrated circuitry of claim 17 wherein the  $Ta_2O_5$   
7 comprising region is the only capacitor dielectric region received between the  
8 first and second capacitor electrodes, and consists essentially of the  
9 substantially amorphous  $Ta_2O_5$  comprising layer and the substantially crystalline  
10  $Ta_2O_5$  comprising layer.

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12 23. A capacitor forming method comprising:

13 forming a first capacitor electrode layer over a substrate;

14 forming a high K capacitor dielectric region over the first capacitor  
15 electrode layer, the high K capacitor dielectric region comprising a high K  
16 substantially crystalline material layer and a high K substantially amorphous  
17 material layer; and

18 forming a second capacitor electrode layer over the high K capacitor  
19 dielectric region.

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21 24. The method of claim 23 comprising forming the high K  
22 substantially amorphous material and the high K substantially crystalline  
23 material to constitute the same chemical composition.  
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1 25. The method of claim 24 wherein the chemical composition  
2 comprises  $Ta_2O_5$ .

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4 26. The method of claim 23 comprising forming the high K  
5 substantially amorphous material and the high K substantially crystalline  
6 material to constitute different chemical compositions.

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8 27. The method of claim 23 wherein at least one of the high K  
9 substantially amorphous material layer and the high K substantially crystalline  
10 material layer contacts at least one of the first capacitor electrode layer and  
11 the second capacitor electrode layer.

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13 28. The method of claim 23 wherein the high K substantially  
14 amorphous material layer contacts at least one of the first capacitor electrode  
15 layer and the second capacitor electrode layer.

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17 29. The method of claim 28 wherein the high K substantially  
18 amorphous material layer contacts only one of the first capacitor electrode  
19 layer and the second capacitor electrode layer.

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21 30. The method of claim 23 wherein the high K substantially  
22 amorphous material layer contacts one of the first and second capacitor  
23 electrode layers and the high K substantially crystalline material layer contacts  
24 the other of the first and second capacitor electrode layers.

1 31 The method of claim 23 wherein the high K capacitor dielectric  
2 region is formed to be the only capacitor dielectric region received between  
3 the first and second capacitor electrode layers, and consists essentially of the  
4 high K substantially amorphous material layer and the high K substantially  
5 crystalline material layer.

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7 32. The method of claim 23 wherein the high K substantially  
8 amorphous material layer is formed to be at least 98% amorphous, and the  
9 high K substantially crystalline material layer is formed to be at least 98%  
10 crystalline.

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12 33. A capacitor forming method comprising:

13 forming a first capacitor electrode layer over a substrate;

14 depositing a substantially amorphous first high K capacitor dielectric  
15 material layer over the first capacitor electrode layer;

16 converting the substantially amorphous high K first capacitor dielectric  
17 material layer to be substantially crystalline;

18 after the converting, depositing a substantially amorphous second high K  
19 capacitor dielectric material layer over the substantially crystalline first high K  
20 capacitor dielectric material layer; and

21 forming a second capacitor electrode layer over the substantially  
22 amorphous second high K capacitor dielectric material layer.

1           34. The method of claim 33 further comprising after the converting  
2 and before forming the second capacitor electrode layer, oxidize annealing the  
3 second high K capacitor dielectric material layer in an oxygen containing  
4 atmosphere at a temperature of no greater than about 600°C and effective to  
5 maintain the second high K capacitor dielectric material layer substantially  
6 amorphous.

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8           35. The method of claim 33 further comprising after the converting  
9 and before forming the second capacitor electrode layer, oxidize annealing the  
10 second high K capacitor dielectric material layer in an oxygen containing  
11 atmosphere at a temperature of from about 300°C to about 550°C and  
12 effective to maintain the second high K capacitor dielectric material layer  
13 substantially amorphous.

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15           36. The method of claim 33 wherein the converting occurs in an  
16 atmosphere which is substantially void oxygen.

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18           37. The method of claim 33 wherein the first and second dielectric  
19 material layers are formed to constitute the same chemical composition.

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21           38. The method of claim 37 wherein the chemical composition  
22 comprises Ta<sub>2</sub>O<sub>5</sub>.



1 39. The method of claim 33 wherein the first and second dielectric  
2 material layers are formed to constitute different chemical compositions.

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4 40. The method of claim 33 wherein the second capacitor electrode  
5 layer is formed to contact the substantially amorphous second high K capacitor  
6 dielectric material layer.

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8 41. The method of claim 33 wherein the first high K capacitor  
9 dielectric material layer is formed to contact the first capacitor electrode layer.

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11 42. The method of claim 33 wherein the first high K capacitor  
12 dielectric material layer is formed to contact the first capacitor electrode layer,  
13 and the second capacitor electrode layer is formed to contact the substantially  
14 amorphous second high K capacitor dielectric material layer.

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16 43. The method of claim 33 wherein the first high K capacitor  
17 dielectric material layer is formed to contact the first capacitor electrode layer,  
18 the second high K capacitor dielectric material layer is formed to contact the  
19 first high K capacitor dielectric material layer, and the second capacitor  
20 electrode layer is formed to contact the second high K capacitor dielectric  
21 material layer.  
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1 44. A capacitor forming method comprising:  
2 forming a first capacitor electrode layer over a substrate;  
3 depositing a substantially amorphous first high K capacitor dielectric  
4 material layer over the first capacitor electrode layer;  
5 oxidize annealing the first high K capacitor dielectric material layer in  
6 an oxygen containing atmosphere at a temperature of no greater than about  
7 600°C;  
8 after the oxidize annealing of the first high K capacitor dielectric  
9 material layer, converting the substantially amorphous high K first capacitor  
10 dielectric material layer to be substantially crystalline;  
11 after the converting, depositing a substantially amorphous second high K  
12 capacitor dielectric material layer over the substantially crystalline first high  
13 K capacitor dielectric material layer;  
14 oxidize annealing the second high K capacitor dielectric material layer  
15 in an oxygen containing atmosphere at a temperature of no greater than about  
16 600°C and effective to maintain the second high K capacitor dielectric  
17 material layer substantially amorphous; and  
18 forming a second capacitor electrode layer over the substantially  
19 amorphous second high K capacitor dielectric material layer.  
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21 45. The method of claim 44 further wherein the first and second  
22 oxidize annealings comprise annealing in an oxygen containing atmosphere at  
23 a temperature of no greater than about 600°C.  
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1 46. The method of claim 44 wherein the converting occurs in an  
2 atmosphere which is substantially void oxygen.

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4 47. The method of claim 44 wherein the first and second dielectric  
5 material layers are formed to constitute the same chemical composition.

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7 48. The method of claim 47 wherein the chemical composition  
8 comprises  $Ta_2O_5$ .

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10 49. The method of claim 44 wherein the first and second dielectric  
11 material layers are formed to constitute different chemical compositions.  
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50. A capacitor forming method comprising:  
forming a first capacitor electrode layer over a substrate;  
depositing a substantially amorphous first high K capacitor dielectric material layer over the first capacitor electrode layer;  
converting the substantially amorphous high K first capacitor dielectric material layer to be substantially crystalline;  
after the converting of the substantially amorphous high K first capacitor dielectric material layer, oxidize annealing the first high K capacitor dielectric material layer in an oxygen containing atmosphere at a temperature of no greater than about 600°C;  
after the oxidize annealing of the first high K capacitor dielectric material layer, depositing a substantially amorphous second high K capacitor dielectric material layer over the substantially crystalline first high K capacitor dielectric material layer;  
oxidize annealing the second high K capacitor dielectric material layer in an oxygen containing atmosphere at a temperature of no greater than about 600°C and effective to maintain the second high K capacitor dielectric material layer substantially amorphous; and  
forming a second capacitor electrode layer over the substantially amorphous second high K capacitor dielectric material layer.

51. The method of claim 50 further wherein the first and second oxidize annealings comprise annealing in an oxygen containing atmosphere at a temperature of no greater than about 600°C.

1 52. The method of claim 50 wherein the converting occurs in an  
2 atmosphere which is substantially void oxygen.

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4 53. The method of claim 50 wherein the first and second dielectric  
5 material layers are formed to constitute the same chemical composition.

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7 54. The method of claim 53 wherein the chemical composition  
8 comprises  $Ta_2O_5$ .

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10 55. The method of claim 50 wherein the first and second dielectric  
11 material layers are formed to constitute different chemical compositions.

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13 add  
14 D2  
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add  
E2

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17 add  
18 F5  
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